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SUMMER FALLOW AT ARDMORE, S. DAK.

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CONTENTS

	Page		Page
Introduction	1	Results with corn and sorgo	7
Soil conditions	2	Methods of fallow	9
Precipitation	2	Quantity of water stored by fallow	11
What is summer fallow?	3	Discussion and conclusions	13
Results with small grains	4	Summary	14

INTRODUCTION

Interest in summer fallow as a method of crop production has increased greatly during the past few years in western South Dakota, eastern Wyoming, and northwestern Nebraska. There are a number of reasons for this, but the most important is the development of power machinery and implements for cultivating fallow. The use of the tractor and combined harvester-thresher has reduced the cost of production of small grains, such as wheat and barley, and has consequently increased their relative importance in the farming system of the section. Small-grain farming to be successful requires a clean-up crop or cultivation to control weeds. On a mixed farm depending on livestock for a considerable proportion of its income a cultivated crop, such as corn, lends itself admirably to this use. The corn provides feed for the livestock and prepares the land for the growth of small grains.

Partly by reason of its lesser adaptation to large-scale farming by the use of power machinery now available, and partly by reason of the lower average acre value of the crop, corn in this section has not been able to meet fully the competition of wheat and barley.

In the use of machinery and in the distribution of labor summer fallow fits well into extensive grain farming. The effectiveness of the fallow has been increased and its cost decreased by the development of implements, such as the duck-foot type of cultivator, for its maintenance.

To compare results obtained from summer fallow with other methods of crop production, a series of experiments have been carried out at the United States Dry Land Field Station, near Ardmore, in the southwestern corner of South Dakota. The results of these experiments, extending from 1913 to 1930, inclusive, are given in this circular. They are applicable chiefly to western South Dakota, eastern Wyoming, and northwestern Nebraska. The elevation of the station is about 3,500 feet.

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The experimental unit was the $\frac{1}{10}$-acre plot. All plots of a crop were of the same variety each year, and varieties were changed only as experience demonstrated that other varieties were better adapted. Uniform treatment was given all plots under the same cultivation methods.

SOIL CONDITIONS

The soil at the Ardmore station is of a medium-brown to dark-brown color and of clay-loam texture to a depth of about 15 inches. A zone of lime-carbonate accumulation encountered at this depth extends down about 2 feet and below it lies the parent material, ranging from clay to gravelly clay, that has accumulated by deposition from river water. The crop-rotation field is underlain by gravel at a depth of 4 to 5 feet. The color and profile correspond closely to that of the Rosebud series, as mapped by the Bureau of Chemistry and Soils, and so far as essential characteristics are concerned it can be designated the Rosebud clay loam. Any other designation that may be given it in the future, when it is included as a part of a detailed soil-survey project, will be based on geological considerations, none of which would be significant from the agricultural standpoint.

The soil at Ardmore absorbs moisture rather slowly. When the surface soil is worked down smooth, a sudden shower may be largely lost by run-off. When the surface is kept somewhat lumpy, ordinary rains are almost completely absorbed. Heavy rains falling within a short period of time may cause the surface soil to run together. When this occurs the loss through run-off is heavy. Allowing the plowed land to stand rough during much of June, when such rains are most likely to occur, reduces the danger of loss by run-off.

PRECIPITATION

The precipitation for each of the six months of the growing season, the seasonal precipitation, and the annual precipitation for the years from 1912 to 1930, inclusive, are presented in Table 1.

TABLE 1.—*Monthly precipitation (inches) during the growing season, seasonal precipitation, and annual precipitation at the Ardmore station from 1912 to 1930, inclusive*

Year	April	May	June	July	August	September	Seasonal, April to September	Annual
1912	2.15	0.80	1.87	1.97	0.83	1.68	9.30	12.89
1913	1.52	2.04	1.59	1.78	1.23	1.50	9.66	13.23
1914	3.27	1.24	3.24	.49	1.79	.75	10.78	13.47
1915	4.26	3.40	6.67	6.01	1.37	4.70	26.41	30.41
1916	1.04	3.61	2.58	1.80	1.90	.02	10.95	13.53
1917	2.74	5.34	1.71	.47	1.99	.43	12.68	15.81
1918	2.85	5.99	1.75	3.49	.44	3.01	17.53	20.26
1919	2.52	2.65	1.50	3.05	.47	.38	10.57	15.28
1920	3.78	5.20	3.10	.77	1.59	.29	14.73	18.43
1921	.52	2.41	4.54	1.26	.55	.46	9.74	12.78
1922	3.23	2.56	2.59	4.07	.78	.15	13.38	17.50
1923	.98	3.80	5.93	.67	3.09	1.52	15.99	18.60
1924	.69	.75	1.95	2.61	.23	1.24	7.47	11.74
1925	1.34	2.02	4.02	2.55	.72	.70	11.35	15.93
1926	.49	2.53	1.80	3.55	2.94	1.09	12.40	16.66
1927	4.06	3.26	3.28	3.33	2.25	1.01	17.19	21.07
1928	.27	1.52	3.67	3.63	.76	.30	10.15	12.05
1929	1.41	2.18	2.21	2.90	1.49	2.71	12.90	15.46
1930	1.93	2.89	1.24	.70	3.01	1.10	10.87	15.71
Mean	2.06	2.85	2.91	2.37	1.44	1.2	12.84	16.36

The mean annual precipitation for the 19 years that records have been kept is 16.36 inches, of which 12.84 inches, or 78 per cent, fell during the growing season. The maximum precipitation was recorded in 1915, when 26.41 inches of rain fell during the growing season and 30.41 inches during the year. The lowest seasonal and annual precipitations were both recorded in 1924—7.47 and 11.74 inches, respectively.

The distribution of rain and the manner in which it falls play an important part in determining the quantity of crop produced and the quantity of water that can be conserved by tillage methods. Rains that fall later than the first week in July are of little benefit to small-grain crops, as the crops are usually near maturity by that time.

The rainfall for 1912 is included in Table 1, because the fallow period for the crop grown in 1913 began in 1912. The rainfall figures explain to some degree the low yields on fallow in 1913. The sod was broken in 1912, after the moisture from the rains of the early spring had been used by the grass. Precipitation during the summer months was below normal, and the storage of water during the season was undoubtedly lower than it would have been had the ground been broken before 1912.

The rainfall figures show the relative unimportance of the winter months in the storage of moisture. Only about one-fifth of the year's precipitation falls during the six months from October to March, inclusive. Much of this precipitation is in the form of snow. When snow falls on frozen ground much of the water is lost by run-off in the spring. Frequently snow blows from cultivated fields and lodges in drifts and in ravines. Only a comparatively small portion of the winter precipitation remains in the soil for the use of crops.

WHAT IS SUMMER FALLOW?

In the more arid portion of the country, summer fallow, or fallow as it is more commonly called, has come to be synonymous with clean cultivation of land where no crop is grown. The most important function of summer fallow in the dry-land region is the storing of moisture. Weed growth removes moisture and destroys the purpose of summer fallow. To be effective, summer fallow must be plowed or cultivated in the spring before weeds have removed much moisture, and cultivation must be given often enough to keep the soil free, or nearly free, from weeds.

During the early years of the experiment the fallow plots were given a large number of cultivations to maintain a dust mulch, in order to conserve moisture. Methods were changed as experience demonstrated that a dust mulch was not necessary and that a relatively rough surface permitted readier penetration of water. Loss of water from the soil below the first few inches is confined almost entirely to that removed by plants. Enough cultivation to keep the soil free from weeds is essential, but any greater amount of cultivation is harmful.

The fallow was plowed in the fall from 1912 to 1916, and in the spring thereafter. From 1912 to 1926 the implements used to keep the fallow free of weeds after plowing were the disk harrow and spike-tooth harrow. Since 1926 the duck-foot field cultivator has been used almost exclusively.

The present practice is to plow from 6 to 8 inches deep between May 20 and June 1. At this time most of the weed seeds have germinated, but the weeds have not grown enough to have removed much moisture from the soil. After plowing, the ground is usually left rough until weeds begin to grow. This does not usually occur until one or more good rains have fallen. A rough, plowed surface is one of the best preventives of run-off if torrential showers occur. After weed growth starts the land is worked with a duck-foot field cultivator. This levels the land somewhat and destroys the weeds, but it leaves the surface soil lumpy. During the rest of the season the duck-foot cultivator is used as often as is necessary to destroy weed growth. In some years a cultivation is given late in the fall, to ridge the soil to prevent soil blowing, to catch snow, and to retard run-off. One plowing and three or four duck-foot cultivations represent all the labor necessary to keep land fallow for a year.

RESULTS WITH SMALL GRAINS

The acreage of wheat greatly exceeds that of any other crop grown in western South Dakota. Spring wheat is most commonly grown, but winter wheat is grown to some extent, especially in the southern part of the State.

Extensive wheat growing is usually associated with a relatively small number of livestock, and wheat growers should be especially interested in any practice that tends to improve yields in poor years and to help in controlling weeds. Study of the yields obtained on fallow, contrasted with those where grain has been grown by other methods, should enable any wheat grower to decide whether fallow can be used with relative advantage on his farm.

Yields of spring wheat and winter wheat on fallow, on disked corn ground, and grown continuously are presented in Table 2. The method of fallow has been described. Corn preceding wheat was grown on both spring and fall plowing. The corn ground in all years was kept as nearly free from weeds as was practicable while the crop was growing. Corn on all plots was harvested with a corn binder early in September each year, and the shocks were removed as soon as dry. The effect of corn on the wheat crop is the effect of corn stubble and not that of standing cornstalks.

TABLE 2.—*Yields of spring wheat, winter wheat, oats, and barley on fallow, disked corn ground, and with continuous cropping at Ardmore, S. Dak., 1913 to 1930, inclusive*

Crop	Previous crop, if any, and tillage method	Number of plots	Acre yields (bushels)																		
			1913	1914 [1]	1915	1916	1917	1918	1919	1920	1921	1922 [1]	1923	1924	1925	1926	1927	1928	1929	1930	Average
Spring wheat	Fallow	9	7.2	0	50.6	18.2	10.2	37.9	15.5	26.5	23.2	0	26.5	18.9	19.4	10.3	34.1	38.2	24.5	12.1	20.7
	Corn, disked	13	.2	0	48.7	23.6	9.7	35.1	9.8	30.2	19.1	0	24.9	8.7	18.6	6.4	33.6	22.3	11.3	11.4	17.4
	Wheat, continuous cropping	4	.6	0	45.5	14.7	6.6	26.7	3.4	22.2	6.4	0	16.7	4.1	9.3	5.8	34.4	10.2	4.5	3.7	11.9
Winter wheat	Fallow	3	8.0	0	37.0	31.6	10.8	21.2	32.5	31.9	32.4	0	21.6	19.7	12.4	7.2	18.3	34.0	22.6	16.8	19.9
	Corn, disked	3	0	0	36.4	30.1	8.5	25.8	18.9	25.2	15.8	0	15.4	5.5	12.6	1.2	23.6	15.6	4.6	14.0	14.1
	Wheat, continuous cropping	4	0	0	29.4	31.3	4.7	15.4	7.5	21.3	4.3	0	15.2	1.7	7.4	5.0	16.3	11.2	.5	0	9.5
Oats	Fallow	6	12.1	0	82.6	40.7	18.4	77.9	36.2	65.3	60.0	0	68.9	22.0	46.2	33.2	79.6	76.5	47.0	29.5	44.2
	Corn, disked	10	.5	0	79.4	47.3	15.4	65.7	22.5	51.1	45.1	0	54.6	13.6	40.0	24.6	59.0	39.3	20.8	29.4	33.8
	Oats, continuous cropping	4	0	0	71.5	28.7	13.9	59.8	12.9	55.8	15.4	0	38.9	7.6	21.0	14.6	68.1	23.5	9.2	11.6	25.1
Barley	Fallow	1	10.0	0	68.0	11.3	7.2	38.2	18.9	37.9	30.2	0	56.3	22.5	57.5	32.5	65.2	59.0	50.6	36.9	33.5
	Corn, disked	1	0	0	49.0	25.4	5.6	60.6	7.7	24.1	20.6	0	55.0	16.3	42.5	27.1	56.5	29.8	22.9	39.4	26.8
	Barley, continuous cropping	4	0	0	56.3	23.3	4.9	34.3	6.2	33.9	8.1	0	41.9	7.4	25.0	14.5	56.2	22.3	9.3	14.5	19.9

[1] Crop destroyed by hail.

No effort was made to control weeds in the continuously cropped plots other than by preventing the introduction of noxious weeds, such as wild oats. Four different methods of cultivation were practiced on the continuously cropped plots—spring plowing, fall plowing, subsoiling, and fall listing for spring wheat; and late fall plowing, early fall plowing, subsoiling, and fall listing for winter wheat.

The average acre yield of spring wheat for the 18 years was 20.7 bushels on fallow, 17.4 bushels on corn ground, and 11.9 bushels on land continuously cropped to wheat. Spring wheat produced 74 per cent more on fallow and 46 per cent more on disked corn ground than it did on land cropped continuously to wheat.

Yields in individual years present some interesting figures. In years when the supply of moisture for the production of grain crops was ample, as in 1915 and 1927, the yields of grain grown continuously were high and not far below those on fallow. Following years when opportunity for storage of moisture was limited, yields on all methods of culture generally were low, but with those on fallow somewhat higher than on other methods. Yields in 1917 and 1926 are examples of this condition. The greatest excess of yields on fallow over those by other methods was shown in fairly dry years following years when there had been an opportunity for fallow to store all the moisture it was capable of holding. Examples of this type are the years 1924 and 1928.

The results show that, while the use of fallow does not absolutely prevent failures, it makes them extremely rare. Not counting the 2 years when hail destroyed wheat on all methods of cultivation, there was only 1 year in 16 when the yield of spring wheat on fallow was less than 10 bushels per acre. During this same period there were 5 years when corn ground produced less than 10 bushels per acre and 9 years when continuous spring wheat produced less than 10 bushels per acre. There were only 4 years, or one-fourth of the time, when the yield on fallow was less than 15 bushels per acre. During 7 of the 16 years spring wheat on corn ground produced less than 15 bushels per acre, and where wheat followed wheat the yield was below 15 bushels per acre in 11 of the 16 years. These records show how effective fallow has been in preventing failure from drought.

Winter wheat produced 18-year average acre yields of 19.9 bushels on fallow, 14.1 bushels on corn ground, and 9.5 bushels when grown continuously. Winter wheat on fallow produced more than double the yield of winter wheat grown continuously.

Winter wheat produced lower average yields than spring wheat, the difference being especially marked following corn and on continuously cropped land. In most years winter wheat was injured to some extent by soil blowing. The yields indicate that spring wheat offers greater possibilities of producing a paying crop than winter wheat, though in some years winter wheat does as well as, or better than, spring wheat.

Oats and barley are the principal feed-grain crops grown in the district. One of the most important points in the consideration of fallow for the production of such crops is the extent to which it assures production even in dry years.

The yields of oats and barley on fallow, disked corn ground, and continuously cropped land are presented in Table 2. The treat-

ments given to the fallow, corn ground, and continuously cropped land were the same as for wheat.

The 18-year average acre yield of oats was 44.2 bushels on summer fallow, 33.8 bushels on corn ground, and 25.1 bushels when grown continuously. Oats on corn ground and on fallow were 35 per cent and 76 per cent more productive, respectively, than oats on continuously cropped land. The response of oats to fallow was nearly the same as for spring wheat, and the comparative yields in the different years were approximately the same. The principal difference between the two is the relatively lower yield of oats on corn ground than of wheat on corn ground. Oats produced more pounds per acre than wheat on fallow and on continuously cropped land and approximately the same on corn ground.

The effectiveness of fallow in preventing crop failure of oats is about the same as for wheat. Excluding the 2 years when hail destroyed the crop, oats on fallow produced a crop of over 20 bushels per acre in 14 of the 16 years. During the same years oats on corn ground fell below 20 bushels per acre in 3 years, and oats continuously cropped produced less than 20 bushels per acre in 8 of the 16 years. Considered as a whole, the responses of spring wheat and oats to different cultural treatments are much the same.

The average acre yield of barley was 33.5 bushels on fallow, 26.8 bushels on corn ground, and 19.9 bushels on continuously cropped land. Only one plot of barley was grown on fallowed land and only one on disked corn ground. For this reason the yields from these two methods of cultivation are probably not so representative as for wheat and oats, where the figures given represent the averages of a number of plots.

Corn ground produced 35 per cent and fallow 68 per cent more barley than continuously cropped land.

The response of barley to cultural treatments is much the same as for wheat and oats. The striking result with barley is its greater yielding power. Expressed in terms of pounds per acre, barley continuously cropped produced within 100 pounds per acre as much as did wheat on corn ground, and barley on corn ground yielded more pounds per acre than did wheat on fallow. Barley on fallow produced more pounds per acre than did any other grain crop. During each year, from 1927 to 1930, 10 acres of barley on fallow have been grown at the station. The production during that period has averaged 47.9 bushels per acre.

The greater yielding power of barley is reflected in an increasing barley acreage and a decreasing oat acreage in the locality. In fact, barley has been so productive that it is being substituted for corn, as far as possible, by many farmers.

RESULTS WITH CORN AND SORGO

Corn is the cultivated crop grown most extensively in this section. Its production works in well with any system of mixed farming. Sorgo is a valuable feed for wintering stock, but it is grown only to a limited extent. Experiments have been conducted to determine the effect of fallow upon the production of these crops. Comparison of the yields of corn and sorgo grown under different methods of cultivation are presented in Table 3, page 8.

TABLE 3.—*Yields of corn on fallow, following small grains, and with continuous cropping, and of sorgo on fallow and with continuous cropping at Ardmore, S. Dak., 1913 to 1930, inclusive*

Crop	Previous crop, if any, and tillage method	Number of plots	Acre yields [1]																	
			1913	1914	1915	1916	1917	1918	1919	1920	1921	1922	1923	1924	1925	1926	1927	1928	1929	1930	Average
Corn (grain)	Fallow	1	0	0	43.4	30.9	16.8	29.6	19.2	27.7	15.3	20.1	31.7	11.5	26.7	17.7	19.7	25.1	18.4	25.0	21.0
	Small grains	34	0	0	39.5	21.5	14.1	22.1	9.4	19.1	7.4	15.4	29.2	2.4	11.7	11.6	38.9	20.7	9.7	1.4	15.2
	Corn, continuous cropping	5	0	0	35.0	25.6	15.1	22.1	6.1	22.7	11.8	13.7	31.4	1.7	15.9	7.7	28.3	18.7	9.8	14.3	15.6
Corn (stover)	Fallow	1	17.8	11.3	40.0	25.0	14.0	20.0	29.0	18.5	22.0	17.0	24.5	25.3	24.5	16.8	15.5	19.4	21.6	12.3	20.8
	Small grains	34	8.6	9.8	37.6	31.1	14.4	21.2	15.0	17.4	19.8	14.5	26.4	19.8	20.1	20.2	37.9	20.1	26.8	11.1	20.6
	Corn, continuous cropping	5	8.9	12.4	36.3	29.8	13.1	19.4	13.8	15.0	21.8	11.2	23.2	13.8	15.5	14.5	19.0	10.1	16.6	11.9	17.0
Sorgo (fodder)	Fallow	1	------	------	------	66.0	24.0	62.0	50.0	36.5	43.5	43.0	64.0	24.5	40.5	41.6	100.5	47.5	40.0	44.0	48.5
	Sorgo, continuous cropping	4	------	------	------	61.5	32.8	68.3	37.1	41.4	42.8	43.0	73.8	20.0	39.1	38.4	91.8	27.8	24.5	33.0	45.0

[1] Bushels of corn (grain) and hundredweights of corn (stover) and sorgo (fodder).

The 18-year average acre yields of ear corn were 21 bushels on fallow, 15.2 bushels after small grain, and 15.6 bushels after corn. Fallow proved to be only 35 per cent more productive than continuous cropping. Corn after small grain produced 0.4 of a bushel less grain per acre than did corn grown continuously.

In the yield of stover, corn after small grain was practically equal to corn on fallow. The difference in stover yield between the continuously cropped corn and that on fallow was relatively much smaller than the difference in grain yield.

The yield of corn on fallow is too low for this practice to be seriously considered. The yields of corn after other methods of cultivation are relatively low in comparison with the yields of small grains. The feasibility of growing corn depends not only on its own yield of grain and stover but also on the relatively good yield of small grain following it.

The 15-year average acre yield of sorgo on fallow was 4,850 pounds of air-dry fodder, and that of sorgo grown continuously was 4,500 pounds. Sorgo shows even less response than corn to fallow, and certainly fallow can not be seriously considered as a method of sorgo production. Even in years of low yields the production of sorgo on fallow does not greatly exceed that of sorgo after sorgo.

No sorgo was grown following small grains in the experimental plots. On larger fields it was as productive following small grains as it was in the continuously cropped plots. The small-grain crops following sorgo did as well as those following corn.

METHODS OF FALLOW

Spring wheat alternated with fallow on four pairs of plots in a test of methods of fallow. In the pair designated H and I the plot to be fallowed was plowed soon after harvest, the average date being August 31. After plowing the land was cultivated with a disk and harrow so that it went through the winter with a smooth, cultivated surface. During the summer of the fallow season it was given the cultivation necessary to keep it free from weeds.

The fallow plot in the pair designated J and K was also plowed in the fall but was left rough over winter. In some years the plowing in this method was later than in the preceding method, the average date being September 17. The cultivation during the fallow summer was the same as for the fallow in H and I.

Plots L and M were left in stubble during the winter and were plowed in the spring after corn-planting time. The average plowing date was May 25. Cultivation necessary to keep the land free from weeds during the summer was given after plowing.

Plowing was delayed on plots N and O until the weeds had made more growth. The average date of plowing for these plots was June 11. Cultivation during the summer was practically the same as for plots L and M.

The fall-plowed plots required considerably more cultivation than did the spring-plowed plots to keep them clean during the summer. In some cases it was necessary to replow the fall-plowed plots the next summer.

The four fallows varied in the time of plowing and in the cultivation that was given after plowing. Two were plowed in the fall and differentiated by working one down smooth at once, while the other went through the winter rough, as left by the plow. The other two went through the first winter in stubble. One was plowed early, before weeds had made much growth, and the other was plowed later.

During the years that the plots were in wheat all plots were treated uniformly. All were given the same spring cultivation and were planted to the same variety of wheat on the same date.

The annual and average yields for the 17 years, 1914 to 1930, are presented in Table 4. The yields secured in 1913 are not given, as the treatment of all fallow plots was practically uniform in 1912. Total failures in 1914 and 1922 were due to hail.

TABLE 4.—*Annual and average yields of spring wheat on four methods of fallow at Ardmore, S. Dak., from 1914 to 1930, inclusive*

Year	Acre yield (bushels)				Year	Acre yield (bushels)			
	Fall plowed and fall cultivated	Fall plowed and left rough	Plowed in May	Plowed in June		Fall plowed and fall cultivated	Fall plowed and left rough	Plowed in May	Plowed in June
1914	0	0	0	0	1924	19.2	18.0	19.2	17.8
1915	47.2	54.3	49.2	51.7	1925	21.5	21.0	22.7	20.8
1916	11.3	13.7	15.8	12.8	1926	10.7	4.7	9.5	11.0
1917	8.8	10.2	9.0	8.8	1927	25.7	21.3	40.0	40.0
1918	31.3	34.2	35.8	34.2	1928	34.2	35.8	35.7	34.2
1919	8.0	15.7	15.5	12.0	1929	27.7	31.5	25.7	26.8
1920	20.7	21.2	22.7	23.0	1930	8.8	9.3	11.7	12.0
1921	23.2	23.2	23.5	23.0					
1922	0	0	0	0	Average	19.1	20.1	21.5	20.8
1923	26.2	27.8	29.8	25.0					

One of the most striking results shown by these experiments is the fact that land plowed soon after harvest, worked down immediately, and given the most intensive treatment was less productive than any other method. The reason for this lies in the fact that land worked down smooth in the fall does not catch snow and therefore loses more of the winter precipitation. The average yield was 1 bushel per acre lower than that of any other method.

Land plowed in the fall and left rough over winter produced a 17-year average yield of 20.1 bushels per acre. In 1927, following a very heavy April snow, the soil in the two fall-plowed fallow plots crusted badly, which greatly reduced their yields. However, the greater crusting of the soil on these two plots was due to their more packed condition, which resulted from a longer fallow period and must be considered a part of the hazard in fall plowing for fallow.

Both of the spring-plowed fallow plots produced yields higher than either of the fall-plowed plots. The average acre yield of the fallow plowed in May was 21.5 bushels, and that of the early-June plowed fallow was 20.8 bushels. Moisture loss from weed growth before plowing on the June-plowed fallow was responsible for the lower yield. Data from other stations conducting similar experi-

ments on the northern Great Plains show that the yields are further reduced by still later plowing.

The results from the methods of fallowing experiments may be summed up as follows: Spring plowing is preferable to fall plowing because of its slightly higher yield and because less cultivation is required to keep the fallow free from weeds. Plowing between May 15 and June 1 is desirable, but plowing may be delayed as late as June 10 at Ardmore without seriously reducing the yield.

Working down fall-plowed fallow in the fall actually reduces the yield. If it is found desirable at any time to plow in the fall, the land should be left rough over winter. The probability of soil blowing is reduced where the land is left rough.

An additional argument in favor of the spring plowing is the fact that much less power is required to plow moist soil than is required to plow soil as dry as it usually is after harvest.

Fallow without plowing has been tried at a number of places in the Great Plains but not at Ardmore. Results at some stations have shown that yields on fallow where a duck-foot field cultivator has been used in place of a plow have been fully as high as on plowed fallow. At other points results less favorable to plowless fallow have been obtained. Where plowless fallow has not been successful, the cause has been heavier weed infestation of grain grown on plowless fallow and not a smaller storage of moisture. When land is kept fallow with a duck-foot cultivator, earlier spring cultivation is required than when the land is plowed. In practice it usually takes two duck-foot cultivations to compensate for the lack of plowing. Land not plowed but kept fallow with a duck foot is less likely to blow than plowed fallow, as more straw is left in the surface soil.

QUANTITY OF WATER STORED BY FALLOW

The actual quantity of water stored by summer fallow during certain of the fallow periods from 1914 to 1929 is presented in Table 5. No records are available for the fallow periods ended from 1921 to 1925, inclusive. The fallow period selected in each case extends from the soil-sampling date nearest harvest to the one nearest seeding time the year after the land was fallowed. The average length of the fallow period for spring-planted crops was about 19 months.

TABLE 5.—*Inches of water stored during certain fallow periods, the precipitation during the fallow period, and the percentage of the precipitation stored during the fallow period at Ardmore, S. Dak., from 1912 to 1929*

Fallow period	Water stored	Precipitation during fallow period	Precipitation stored	Fallow period	Water stored	Precipitation during fallow period	Precipitation stored
	Inches	*Inches*	*Per cent*		*Inches*	*Inches*	*Per cent*
1912–1914	2.89	16.55	17.5	1924–1926	5.18	22.84	22.7
1913–1915	6.48	21.84	29.7	1925–1927	7.83	29.16	26.9
1914–1916	7.52	39.55	19.0	1926–1928	5.70	29.24	19.5
1915–1917	4.38	23.71	18.5	1927–1929	2.22	18.98	11.7
1916–1918	5.06	23.65	21.4				
1917–1919	5.99	26.09	23.0	Average	5.25	25.62	20.5
1918–1920	4.45	30.23	14.7				

The quantity of water stored was determined by measuring the amount present in the soil at harvest and determining the increase between that time and seeding time. Determinations were made in percentages of the dry weight of the soil and converted to inches of water by means of a determined weight of the soil. These soil weights are only approximate, but they are so nearly correct that no material error is present.

The weights per cubic foot of soil at Ardmore for the different foot sections are: First foot, 64 pounds; second foot, 88 pounds; third foot, 94 pounds; and fourth foot, 91 pounds.

The inches of water stored during certain fallow periods from 1912 to 1929 and the percentage that such quantity is of the precipitation during the period are given in Table 5. The percentage of the precipitation that was stored ranged from 11.7 for the fallow period ended in 1929 to 29.7 for the period ended in 1915. The greatest quantities of water stored were for the fallow periods ended in 1916 and 1927, when 7.52 and 7.83 inches of water, respectively, were stored. In both of these years the soil in all of the first 4 feet contained all the moisture that it was capable of holding. In several years, particularly in 1914 and 1929, the soil was capable of holding considerably more water than it did at the end of the fallow period.

The average percentage of the precipitation stored was 20.5. At first glance this would appear to be a small proportion, but it represents all that could be stored by good fallowing methods. The greater part of the year's precipitation falls during the summer months when temperatures are high and evaporation is rapid. Drying of the surface soil following rains accounts for nearly all the loss of water. This loss is not preventable. Small rains add practically no moisture to the soil. A rain of 0.25 inch wets a dry soil to a depth of not much more than an inch. Cultivation after such a rain merely hastens evaporation. Water penetrates to a depth beyond the reach of evaporation only during heavy rains or frequent light showers when one rain falls before the moisture from the preceding shower has evaporated.

As small as is the percentage of moisture stored, the quantity represents on an average nearly all that the soil can hold. The average quantity stored is 5.25 inches. The soil is capable of holding about 7.50 inches of available water. The 7.50 inches of water represents the difference between the soil when it is dry to crops to a depth of 4 feet and when it contains all the water it is capable of holding to that depth. In several of the years the soil contained available water at harvest. The quantity of additional water that could be stored in these years was reduced because the storage capacity of the soil was already partly utilized.

The striking feature of fallow is the great increase in yields of crops caused by the comparatively small quantity of water stored. Determinations of the quantity of water present in the spring in wheat plots not fallowed show that an average increase of three bushels of wheat per acre was secured for each inch of water stored by fallow above the quantity stored in other plots in the spring.

DISCUSSION AND CONCLUSIONS

The actual and the relative production of crops on fallow and on other methods of preparation have been presented, but other factors than yield help to determine whether fallowing would be profitable or advisable on any particular farm. So much depends upon the type of farming practiced, the farm organization, and the disposition to be made of the farm products obtained that it is not possible to make a general recommendation. This discussion presents both the factors that favor the use of fallow and those that make its use inadvisable. With knowledge of the comparative yields that may be expected from the different cultural methods, each farmer should be in a position to decide whether or not the use of fallow would fit into his farming operations.

Fallow has been comparatively little used in western South Dakota, although yields there are increased fully as much by it as they are in sections where fallowing is a common farm practice. This has been principally due to the greater competition offered by corn in the farming system of western South Dakota, where the growth of corn as a feed for livestock is an important item.

The yields of grain on continuously cropped land have averaged a little more than half as high as those on fallow at Ardmore. This means that if all the land is planted to grain each year, more bushels of grain can be produced on a given acreage than would be produced if half the land were in crop and half in fallow. Where all the land is in crop, however, all of it must be prepared, seeded, harvested, and threshed. This is more expensive than fallowing half and cropping half.

With the land all in crop each year there would be a very high production in some years and failures or near failures in many others. With a portion of the land in fallow, production would be much lower in good years but higher in years of partial failure. The stabilizing influence of the better-distributed production is important.

In comparison with grain continuously cropped, fallow gives a better distribution of yields between years, with much less frequent failures, makes possible the handling of more land with the same equipment or the same amount of land at a less expense and affords better control of noxious weeds.

In comparison with corn ground as a preparation for small grain, fallow gives a better distribution of grain yields between years, makes possible the handling of a given acreage at a smaller expense, and distributes labor better, particularly on farms where haying and corn cultivating interfere with each other.

The use of corn instead of fallow provides for the production of a greater quantity of feed or cash crops on a given acreage; it is a cropping system better adapted to a type of farming in which livestock growing is a major enterprise. Corn is one of the surest feed crops in western South Dakota, but it is not highly productive on the heavier soils. Corn after corn or small grain does not produce so many pounds of grain per acre as does barley grown after barley. Small grains following corn, however, produce higher yields than they do after grain. The value of corn as a crop lies fully as much in its effect on the succeeding crop as in the value of the corn itself.

The comparisons of fallow with continuous cropping and with a rotation of corn and small grains do not mean that any one method must be employed exclusively. A highly efficient management may succeed with a mechanized agriculture of fallow and small grains. On the other hand, fallow may be replaced entirely by cultivated crops. There appears, however, to be a place for a moderate amount of fallow on many farms, both as an insurance against failure and to free the land of weeds.

The employment of certain methods or practices and the avoidance of others are necessary to the successful use of fallow. One should not attempt to fallow dry-farm land unless prepared to keep it free from weeds. Timely rather than numerous operations are required. A weedy summer fallow is a waste of time and labor in dry farming. Equipment adapted to the purpose is essential. Implements that kill weeds without pulverizing the soil are best. The surface should not be worked down to form a dust mulch. Such treatment usually results in the pulverized soil blowing from the field in early spring and piling up along fence rows or other obstructions. Fallow should be plowed in May or early June, worked as little as is necessary to control weeds, and ridged in the fall at right angles to the prevailing winds to prevent soil blowing. Handled in this way fallow offers a maximum of returns for a minimum of effort.

SUMMARY

The most important function of summer fallow is the storing of moisture, and the most important objective in the cultivation of fallow is the control of weeds. After plowing the land, three or four cultivations with the duck-foot cultivator have been sufficient to maintain the fallow for a year.

Fallow prepared by spring plowing gave slightly higher yields and required less cultivation to keep down weeds than fallow prepared by fall plowing. Less power is usually required to plow in the spring than in the fall.

With an average precipitation of 25.62 inches over 11 fallow periods, the water stored in fallowed land averaged 5.25 inches, or 20.5 per cent of the total precipitation.

Fallow tended to eliminate crop failure and to equalize production between years.

Spring wheat produced 74 per cent more on fallow and 46 per cent more on disked corn ground than on land continuously cropped to wheat; for winter wheat the respective increases were 109 per cent and 48 per cent. Spring wheat usually exceeded winter wheat in yield. The relative yields of oats and barley on fallow and other methods of culture were much the same as those of spring wheat. Barley has materially exceeded wheat and oats in yield and is largely replacing corn in the area represented by the Ardmore station. Corn on fallow produced only 35 per cent more than on continuously cropped land. Fallowing as a preparation for corn is not justified. Yields of small grain following corn are relatively good, and corn is a valuable crop in the rotation, especially on farms that have livestock. Sorgo showed little response to fallow in comparison with continuous cropping.

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